Although stratospheric background aerosol is nonabsorbing, the particles injected by the Pinatubo volcanic eruption were large enough to cause infrared warming (Fig. 1). In the Arctic stratosphere, the existence of soot aerosol (arguably from aircraft) increases heating rates from a fraction of a degree per day to about two degrees per day, with possible implications to dynamics and chemical reaction rates.

The presence of clouds is critical for an assessment of aerosol forcing. In the presence of clouds at altitudes higher than the aerosol layer, the aerosol forcing is similar to a cloud-free scenario, albeit at a reduced rate. If the clouds are below the aerosol layer, aerosols primarily reduce cloud-associated solar flux losses such that cooling is not just reduced but can change to warming. Thus the removal of lower-level clouds turned weak net flux gains (warming) into weak net-flux losses (cooling). S. Kinne of NASA Goddard Space Flight Center collaborated with the Ames investigators.

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Analysis of SOLVE Observations of PSCs and Implications for the Evolution of the Arctic Vortex

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In-situ measurements of polar stratospheric clouds (PSCs) made from the ER-2 aircraft during the SAGE III Ozone Loss and Validation Experiment (SOLVE) have revealed new information about the composition and properties of these clouds. Model results have been compared with the ER-2 measurements in order to refine understanding of the cloud microphysics.

Measurements made by the Multiangle Aerosol Spectrometer Probe (MASP) reveal that most particles generally appear to be liquid-phase. Growth of these particles was observed at temperatures near 192 kelvin (K), consistent with the predicted behavior of ternary nitric acid/dihydrogen sulfate/water solutions ($HNO_3/H_2SO_4/H_2O$). Even at warmer temperatures, starting as air cools below 196 K, some swelling of the particles is apparent. The correlation of this growth with total available HNO_3 indicates that HNO_3 condensation is responsible. The observations have been compared with predictions of several ternary solution models with generally good agreement. The presence of liquid-phase particles has implications for the long-term evolution of the Arctic winter. The widespread persistence of liquid particles constrains understanding of freezing processes, especially in air parcels that have experienced extensive denitrification. No significant differences in particle size distributions exist between highly denitrified and less denitrified air parcels, suggesting that very few particles are removed by the processes causing denitrification.

However, a very small fraction (<0.1%) of the particles did freeze during the winter, forming solid-phase HNO_3-containing particles that were observed both by the MASP and by the NO_y instrument. The presence of these frozen particles cannot be explained by current laboratory data on aerosol freezing, in which freezing occurs only at temperatures several degrees below the ice frost point. Alternative formation mechanisms, in particular homogeneous freezing above the ice frost point and heterogeneous freezing, have been explored using the microphysical model. Homogeneous freezing at a rate of 10^4 cubic centimeters per second ($cm^{-3}s^{-1}$) produces particles comparable to observations. However, the PSCs form too frequently (observations often show a lack of solid-phase PSCs well below the nitric acid trihydrate (NAT) condensation point), and the altitude variation is not well captured. For homogeneous freezing to explain the observations, the freezing rate must have a complex dependence upon the local conditions.

On the other hand, PSCs that form by heterogeneous freezing are strongly affected by the winter-long PSC processing; that is, denitrification removes most of the nuclei. The resulting model correlation between denitrification and particle concentration is comparable to the ER-2 observations. In addition to providing an explanation for the occasional absence of solid-phase PSCs, this process also explains why denitrification did not exceed 80%.

To understand the winter-long implications of these findings, the model has been run from November to mid-April, using a large set of trajectories that provided representative coverage of the entire Arctic vortex through the period of PSC formation and ozone depletion. The various possible freezing processes have been shown to have different characteristics in terms of the overall extent of frozen particles, the evolution of the PSCs, denitrification, and dehydration. Scenarios with freezing above the ice frost point lead to widespread denitrification. This denitrification enhances the ozone loss at the end of the winter by up to 30%, as long as the vortex remains stable until late March.

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Global Aerosol Climatology Project

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In June and July, 2000, Ames personnel participated in the Puerto Rico Dust Experiment (PRIDE), a multi-agency field study of the radiative, microphysical, and transport properties of Saharan dust. There were two primary objectives: (1) determine the extent to which the properties of dust particles and the spectral surface reflectance of the ocean surface need to be known before remote sensing systems can accurately determine optical depth and flux; and (2) evaluate/validate the skill with which the Naval Research Laboratory's Aerosol Analysis and Prediction System (NAAPS) predicts the long-range transport and vertical distribution of African dust.

The results of these efforts will support U.S. Navy and NASA applied science objectives on satellite validation and the prediction of dust-induced visibility degradation. In addition, secondary efforts of PRIDE will address in situ issues of coarse mode particles and basic research issues on climate forcing, geochemical cycles, and meteorology.

Ames' specific contributions to PRIDE were to provide measurements and analyses of solar spectral fluxes. The Ames Solar Spectral Flux Radiometer (SSFR) was deployed on the Space and Naval Warfare Systems Command (SPAWAR) Navajo aircraft, measuring upwelling and downwelling spectral irradiance